PUERTO RICO AND VIRGIN ISLANDS PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 42* and *Technical Paper No. 53*

Ninth Progress Report
1 July 2002 through 30 September 2002

Hydrometeorological Design Studies Center
Hydrology Laboratory

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The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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Update of *Technical Paper No. 42* and *Technical Paper No. 53*

1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for Puerto Rico and the Virgin Islands. Current precipitation frequency estimates for the area are contained in *Technical Paper No. 42* "Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands" (U.S. Weather Bureau 1961) and *Technical Paper No. 53* "Two- to ten-day rainfall for return periods of 2 to 100 years in Puerto Rico and Virgin Islands" (Miller 1965). The new study includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Puerto Rico and Virgin Island study area and use accepted statistical methods. The study results will be published as a Volume of NOAA Atlas 14 on the internet using web pages with the additional ability to download digital files.

The study area covers Puerto Rico and the U.S. Virgin Islands of St. Thomas, St. John and St. Croix. The study area is currently divided into 7 homogeneous climatic regions for analysis (Figure 1).

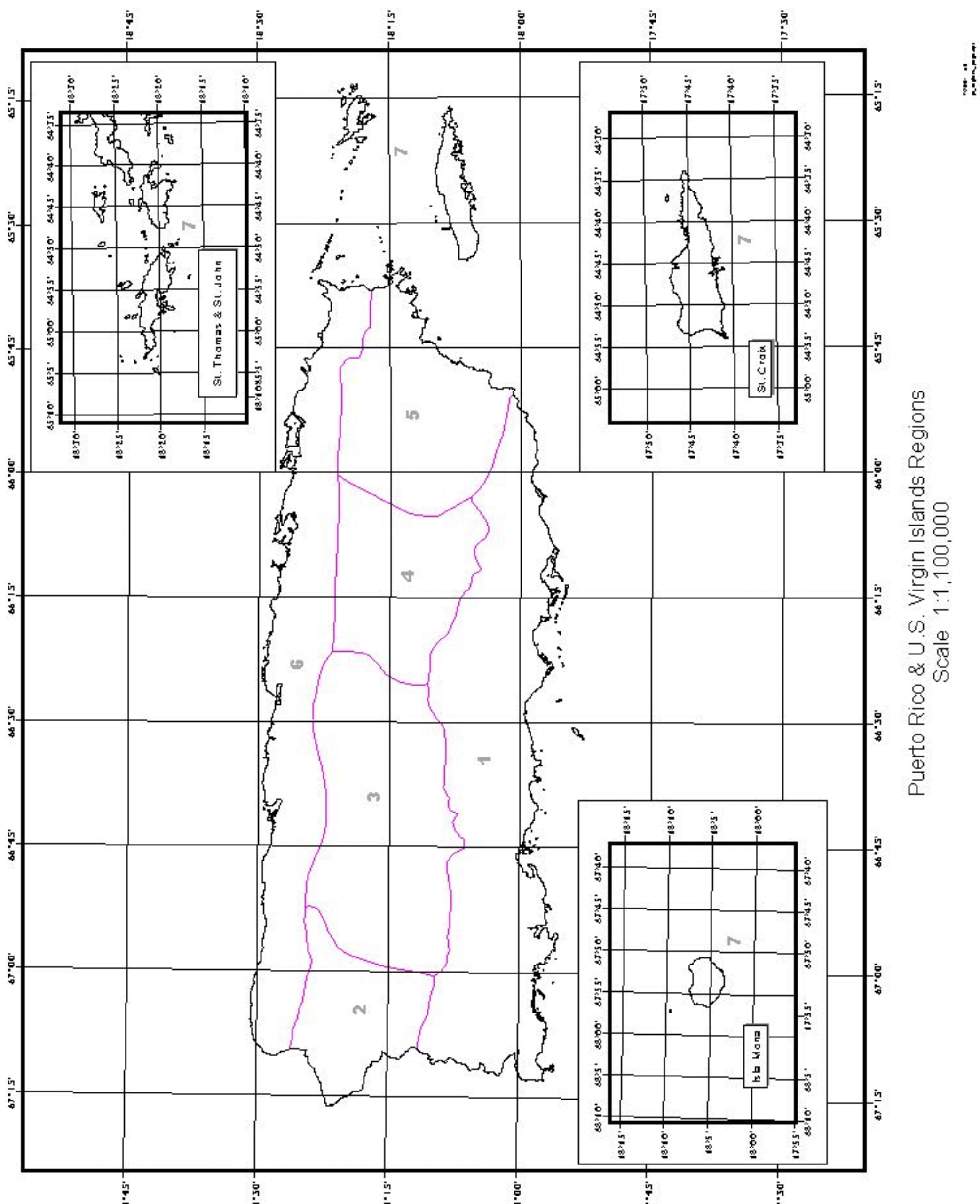


Figure 1. Puerto Rico Precipitation Frequency study area and region boundaries.

2. Highlights.

Work has begun on adding the most recent data to the daily, hourly, and n-minute datasets. Daily data has been formatted and added and is being quality controlled. Additional information is provided in Section 4.1, Data Collection and Quality Control.

Internal consistency software was revised to adjust quantiles from 1-hour through the 24-hour duration for hourly-only stations. Software was developed to adjust quantiles for co-located hourly and daily data, particularly across the 12-hour to 24-hour durations where disconnects in Semiarid Southwestern United States results were observed. Lastly, software has been written to calculate conversion factors from annual maximum series to partial duration series which will be part of the final deliverable. Additional information is provided in Section 4.2, Development of Software.

On July 30, 2002 Geoff Bonnin and Tye Parzybok traveled to the Spatial Climate Analysis Service (SCAS) at Oregon State University, Corvallis, Oregon to discuss and obtain the first draft PRISM-interpolated Semiarid mean annual maxima (a.k.a. "index flood") grids for 1-hour and 24-hour. The successful all-day meeting involved technical discussions about the grids and PRISM, which will be applied to produce the grids for Puerto Rico. Additional information is provided in Section 4.3, Spatial Interpolation.

The Semiarid observing-site peer review allowed users to not only review the Semiarid precipitation frequency estimates, but the Precipitation Frequency Data Server (PFDS as well. The PFDS held up well during its first debut, and a tremendous amount of valuable input was received and quickly incorporated into the PFDS. Additional information is provided in Section 4.4, Precipitation Frequency Data Server.

Progress towards the development of depth-area-duration (D-A-D) reduction relationships for areas from 10 to 400 square miles continues. The progress includes the identification of four additional study areas, completion of quality control on the existing eight study areas, and testing of the initial computer programming. Additional information is provided in Section 4.5, Depth Area Duration Study.

3. Status.

3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percent completed per task. Past status reports should also be referenced for additional information.

Puerto Rico study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [90%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

Additional data has been formatted and added to the daily dataset. It is currently being quality controlled.

L-Moment Analysis/Frequency Distribution for 5 minute to 60 days and 2 to 1000 years [0%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

Internal consistency software was revised to process hourly-only stations through the 24-hour duration and to mitigate disconnects between co-located daily and hourly data.

Spatial Interpolation [0%]:

- Create mean annual maximum (a.k.a. “Index flood”) grids with PRISM for each duration (1-hr, 2-hr, 3-hr, 12-hr, 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, 60-day)
- Apply a precipitation frequency map derivation procedure, known as the cascade residual add-back (CRAB) procedure to create a total of 162 grids. The same procedure will be used to create 162 upper and 162 lower bound precipitation frequency grids. (See Section 4.6 Spatial Interpolation for more details.)
- Apply study-wide conversion factor to the 60-minute precipitation frequency grids to calculate the n-minute (5-, 10-, 15-, and 30-minute) grids

Output of spatially interpolated mean annual maxima (a.k.a. “index flood”) from PRISM has been reviewed. Software has been written to convert "index flood" grids to precipitation frequency maps. Once initial "index flood" grids are prepared, the remaining precipitation frequency maps can be quickly generated.

Peer Reviews [0%]
- Lead review of point precipitation frequency estimates
- Lead review of spatial interpolation grids

Data Trend Analysis [10%]:
- Analyze linear trends in annual maxima and variance over time
- Analyze shift in means of annual maxima between two time periods (i.e., test the equality of 2 population distribution means)

Temporal Distributions of Extreme Rainfall [10%]:
- Create graphs of percentage of precipitation maxima in each month of a year
- assemble hourly data by quartile of greatest precipitation amount and convert to cumulative rainfall amounts for each region
- sort, average, and plot time distribution of hourly maximum and median events for different climatological regions and seasons

Deliverables [15%]:
- Prepare data for web delivery
- Prepare documentation for web delivery
- Write hard copy of Final Report
- Publish hard copy of Final Report

A detailed outline of the final documentation for the methodology is being written. The Precipitation Data Frequency Server (PFDS) has been modified to reflect changes suggested by reviewers.

Additional Work:

Spatial Relations (Depth-Area-Duration Study) [40%]:
- Obtain hourly data from dense-area reporting networks
- QC and format data from dense networks
- Compute maximum and average annual areal depth for each duration from stations from each network
- Compute ratio of maximum to average depth for all durations and networks and plot
- Prepare curves of best fit (depth-area curves) for each duration and network

Depth Area Duration (DAD) reductions for areas from 10 to 400 square miles are being updated for the entire United States and will be presented in a separate volume of NOAA Atlas 14.

4. Progress in this Reporting Period.

4.1 Data Collection and Quality Control.

Work has begun on adding the most recent data to the daily, hourly, and n-minute datasets. Daily data from the National Climatic Data Center (NCDC) through 2001 has been downloaded, formatted and added to the daily dataset. The digitized TD3206 daily dataset from NCDC for the time period before 1949 has also been added. Quality control has begun on these data. Extreme daily values are being verified. Nearby stations that meet the criteria (within 1-3 miles and 100-500 feet) will be merged. T-tests will be conducted on stations to be merged to ensure that their data are from the same population.

Hourly NCDC data from 10/1998 through 2001 will also be added to the dataset. 15-minute USGS data from 5/1999 through at least 9/2000 will be added to the 15-minute dataset. The NCDC 15-minute dataset, that was previously not included due to poor quality concerns, will be revisited. If the data are found to be acceptable, they will be added to our dataset. Finally, recent NCDC n-minute data after 6/1997 will also be added.

4.2 Development of Software.

Internal consistency software was revised to adjust quantiles through the 24-hour duration for hourly-only stations. Cases where a shorter duration has an estimate that is higher than the next longer duration (e.g., 2-hr = 1.9 and 3-hr = 1.5) are mitigated with a practical adjustment using ratios based on the 1-hour duration.

Software was developed to adjust quantiles of co-located hourly and daily stations, particularly across the 12-hour to 24-hour durations where disparities occur due to gage differences. This adjustment assumes that the daily 24-hour quantiles are true because they are based on our most consistent values and generally have longer record lengths. The method preserves the hourly distribution for 60-minute through 12-hour quantiles at a given hourly station. It then adjusts the quantiles using ratios based on means and regional growth factors (RGFs) since these are the primary parameters in calculating quantile estimates and thus are the major contributors to any observed disconnect between the hourly 12-hour and 24-hour estimates. The software was modified to run on all co-located stations on a region-by-region basis.

Software has also been written to calculate conversion factors from annual maximum series to partial duration series. This software will be tested and run for all durations and return frequencies. The AMS to PDS ratios will be averaged for each region and reported in the final deliverable.

4.3 Spatial Interpolation.

On July 30, 2002 Geoff Bonnin and Tye Parzybok traveled to the Spatial Climate Analysis Service (SCAS) at Oregon State University, Corvallis, Oregon to discuss and obtain the first draft PRISM-interpolated Semiarid mean annual maxima (a.k.a. “index flood”) grids for 1-hour and 24-hour. The successful meeting addressed how PRISM (Parameter-elevation Regressions on Independent Slopes Model) spatially interpolates mean annual maxima values to grids. It was concluded at the meeting that PRISM was doing an excellent job and was properly parameterized to spatially interpolate point index flood values.

The draft “index flood” grids for the Semiarid Project allowed HDSC to fully test the precipitation frequency map derivation procedure, known as the cascade residual add-back (CRAB) procedure. This process will be used to produce the precipitation frequency maps for the Puerto Rico. The CRAB procedure provides a method to smooth discontinuities that may arise between regions as a result of the regionally estimated shape factors and in cases where stations did not conform to any region. A brief description of the process follows.

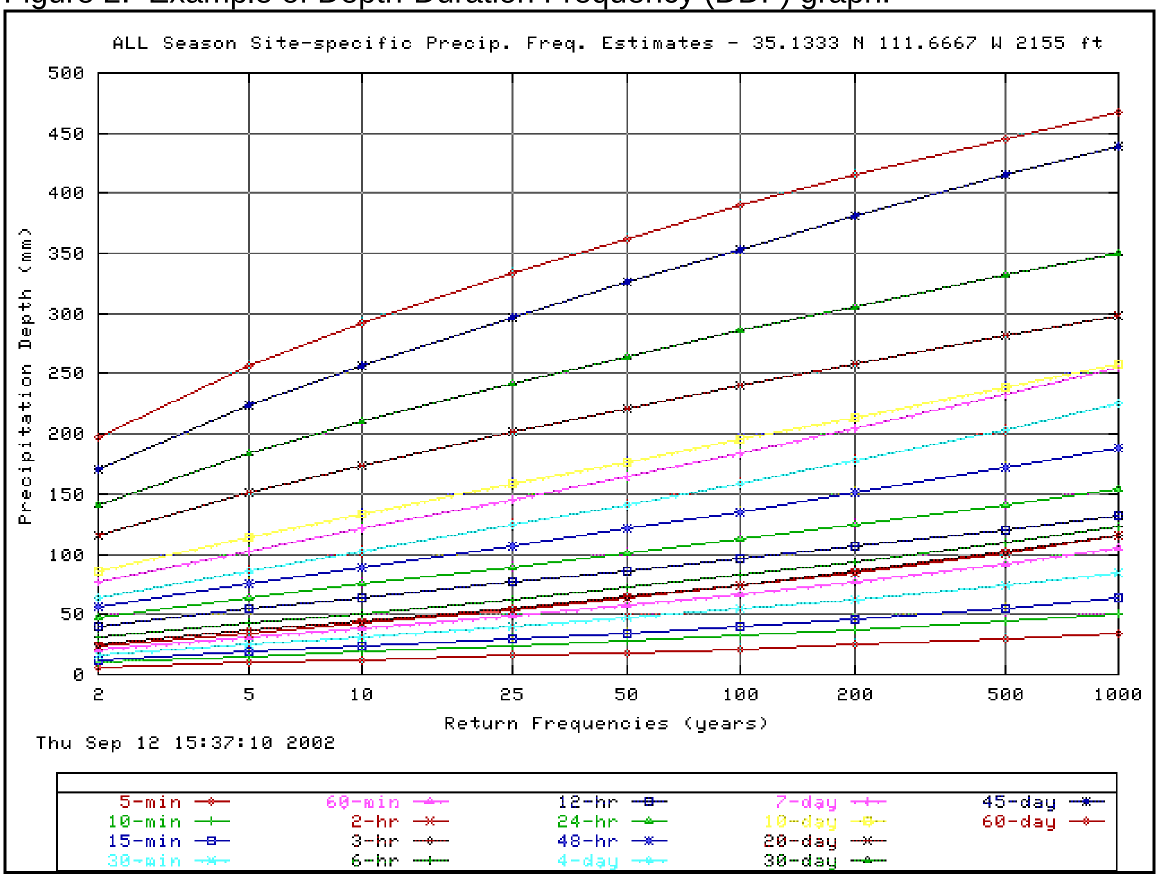
CRAB is a derivation process that utilizes the strong, linear relationship between a particular duration and frequency (e.g. 50-year 24-hour) and the next higher frequency (e.g. 100-year 24-hour). In fact, this relationship within a region is a constant obtainable from the regional growth factors. With the CRAB procedure however, a global (all-region) relationship is developed based on actual observing-site data, then the linear relationship is applied to the preceding grid (i.e. 50-year 24-hour) to establish a first guess 100-year 24-hour grid. Knowing regional differences occur, residuals (actual minus observed) are calculated for each observing-site and then normalized (divided by) by the preceding estimate (50-year 24-hour). These (point) normalized residuals are then spatially interpolated to a grid. The resultant grid is then de-normalized by multiplying it by the preceding grid to obtain a grid of actual residuals, in inches. The last step is to simply add the residual grid to the first guess grid to arrive at the final 100-year 24-hour grid. The process, as the term cascade implies, utilizes a previously derived grid to derive the next grid. So the same process is followed for deriving the 200-year 24-hour grid, but instead of the 50-year 24-hour grid being used as the predictor, the new 100-year 24-hour grid is used.

4.4 Precipitation Frequency Data Server.

The Precipitation Frequency Data Server (PFDS) is an internet-based tool that will be used to deliver precipitation frequency estimates and related information for the Puerto Rico Project. As part of the Semiarid peer review process, a tremendous amount of valuable input was received regarding the PFDS. Changes were made accordingly resulting in a more user-friendly version.

In order to provide users a complete perspective of precipitation frequency estimates, a new graph is now part of the precipitation frequency output page; the Intensity-Duration Frequency (IDF) output remained the same. An example of the popular new graph is shown in Figure 2.

Figure 2. Example of Depth-Duration Frequency (DDF) graph.



4.5 Spatial Relations (Depth Area Duration Study).

Progress towards the development of depth-area-duration (D-A-D) reduction relationships for areas from 10 to 400 square miles continues. Four additional study areas (three in California and one in Arizona) have been identified and will likely be included in the D-A-D study. Quality control on the existing eight study areas has been completed. A study area in the Middle Atlantic area may also be used. No areas in Puerto Rico were found to be suitable. The initial computer programming has been written and successfully tested on two study areas. The secondary D-A-D programming continues and will be completed sometime early in the next quarter. Upon completion, the final D-A-D reduction relationships will be available for use in basins throughout the continental United States. The lack of suitable dense networks in Puerto Rico and the U.S. Virgin Islands raises the question of the validity of the results in those areas. Should we become aware of any networks in Puerto Rico and the U.S. Virgin Islands we may have overlooked we will add them to the analysis.

Table 1. Dense Area Rain Gauge Networks in D.A.D. Study.

Depth Area Duration Study Areas	**Data Extraction & Re-Formatting**
Walnut Gulch, AZ	X
Reynolds Creek, ID	X
Tifton, GA	X
Hastings, NE	X
Alamogordo Creek, NM	X
Safford, AZ	X
Santa Rita, AZ	X
Cochocton, OH	X
Danville, VT	X
Chicago, IL (NCDC stations)	X
Riverside, CA	X
Maricopa County, AZ	X
Ventura County, CA	
Santa Clara County, CA	
Santa Barbara County, CA	

5. Issues.

No issues this quarter.

6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section.

Data Collection and Quality Control [October 2002]
Trend Analysis [November 2002]
Temporal Distributions of Extreme Rainfall [December 2002]
L-Moment Analysis/Frequency Distribution [January 2003]
Peer Review Point Estimates [February 2003]
Spatial Interpolation [May 2003]
Precipitation Frequency Maps [May 2003]
Documentation [May 2003]
Publication [May 2003]

Spatial Relations (Depth Area Duration Studies) [January 2003]

6.1 Data Collection and Quality Control.

During the next quarter, the updates for the daily, hourly, and n-minute datasets will occur. The task involves data collection, formatting and quality control. Longer durations will be extracted upon the completion of the update and quality controlled. The complete update and quality control should take no longer than 4 weeks of working time.

6.2 L-Moment Analysis/Frequency Distribution.

A comprehensive L-moment statistical analysis will be done on all data and regions will be reassessed. The tasks involved with the precipitation frequency analysis will take roughly two months for the Puerto Rico and Virgin Islands study area.

6.3 Spatial Relations (Depth Area Duration Study)

The data for all study areas will be extracted and re-formatted during the next quarter. Software development will also be completed. If additional dense-area-networks are available, they will be added to our database.

References

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